capacities, and the stimulated energies of our text-book makers, to keep our place in the struggle. But grant the truth of the sad presages of those who see the deluge in free trade, can we afford either the principle or the effects of levying a poll-tax on education?

WHIRLWINDS, CYCLONES, AND TORNADOES.[1]—VIII.

THE barometer was falling more and more rapidly, and the wind blowing with increased violence from the north, in the example that was described. Then, if a transparent storm-card, drawn to proper scale after the pattern of fig. 9, be placed on the chart so that its strong north wind shall pass the position of the vessel, it will give the best indication of the general form of the hurricane; and a course may be laid by which the dangerous centre will be avoided. In this case, the safest course will be to run southward, or a point or two west of south, till the barometer begins to rise; and then, if desired, a more easterly course may be followed. Even if the vessel be on its way to a European port, this will be its safest method of avoiding the storm; for, in attempting to beat against the wind and leave the storm to the south, there is too much risk that its increasing strength will prevent the vessel making sufficient headway to escape being caught in the central whirl: it would be better to sail around the southern side of the storm, and, after the centre had passed on the west, then shape a north-easterly course with the wind on the starboard beam. Sometimes it has happened from ignorance of such sailing-rules as these, or from inability, even with their aid, to escape from the sudden violence of a storm, that a vessel finds itself on the storm-track at the time of the passage of the centre; and there is then observed the peculiar and dreadful calm within the whirl, to which sailors have given the name of 'the eye of the storm.' Let us suppose, in the example given above, that the vessel endeavored to force its way against the increasing north wind, and, failing in this, remained on the path of the storm till the centre advanced on it. During its approach there will be no very marked change in the direction of the wind; but its force increases even beyond what seems its greatest possible strength, and goes on increasing, blowing in tremendous and terrible gusts, till the vessel is stripped of its canvas, and the yards and masts are cracked and broken away, and the hull lies helpless and unmanageable. Rain falls in driving torrents, and the sea rolls in great broken waves. The roaring of the winds rises to a screaming pitch; and when at its most fearful strength, it suddenly dies away. In five minutes, perhaps even less, the air is quiet; and only the heavy sea, and the commotion of the clouds, and a distant fading sound of the retreating wind, tell of the violence that has passed by. The vessel is in a cushion of quiet air left under the core of the storm. There is generally but a short time given to suffer the suspense of this unnatural quiet. In half an hour or an hour, according to the size and rate of motion of the storm, the centre passes away, and the opposite side of the whirl suddenly falls on the unhappy wreck, coming again with all the roar and fury that was felt before, but now blowing in the opposite direction,—a terrific hurricane from the south, chopping the waves into the dreaded cross-sea, where the water rises in pyramids instead of in linear crests, and changes its form so rapidly and with such broken rhythm as to strain great leaks in the worn-out hull, and leave it to founder in clearing weather, while the storm goes on in its destructive path.

There is yet much to be learned concerning the curves followed by the winds in these storms. The diagrams, as described above, are based on observation and theory, but must be regarded only as provisional until proved by the average of many more observations than have yet been made. Rules for various cases may be easily devised on the plan above described, but they are not infallible: there is still much to be done in perfecting them. Only one additional point need be mentioned: care is needed to avoid sailing after and overtaking a slow-moving storm, and so falling into its power. This would seldom happen in our latitude, but might well occur in the Indian Ocean, where some storms have been found to rest almost stationary over one district of the sea for more than a day. A case is reported where a vessel thus fell into the dangerous whirl, and could not escape, but was carried round and round the centre, while scudding under bare poles, till it made five complete revolutions before the storm left it behind.

There remains to be described the storm-flood produced when a storm runs upon a low shore, as often happens at the head of the Bay of Bengal. The cyclone advances with growing strength till it reaches the flat delta of the great Indian rivers. It finds the land here perfectly level, and so little raised above the water that its cultivated surface has to be pro-

[1] Continued from No. 48.

tected from river-overflows by dikes ten or twelve feet high built along the shores. But the inblowing winds brush the water of the bay up against the land; the diminished atmospheric pressure about the storm-centre allows the heavier surrounding air to lift the water here, and for every inch that the mercury falls in the barometer the water will rise a foot; the rain alone may contribute nearly a foot of water in a day; and finally, if a strong tide conspire with these other causes, a great flood is produced, that overwhelms even the dikes, and drowns out all the low country; and the poor people, unprovided with sufficient means of escape from the winds and the waters that come from above and below, are lost by the thousand. Six storms alone, that have devastated this coast since 1700, have, if the records can be trusted, destroyed over half a million lives.

The disappearance of a storm has already been alluded to. The storm will fail, or greatly decrease in strength, when running from the sea on the land; for friction here is greater, and there is less moisture in the air from which heat can be obtained to overcome the increased friction and continue the existence of the disturbance. Again: the storm must decrease in intensity as it recedes far from the equator; for it then enters regions of less warmth, and consequently less moisture. Finally, it must end when the updraught caused by heat derived from the falling rain fails to throw the overflow outside of the storm's limits; for then more air enters the storm than flows out of it, and the pressure at the centre will increase. The reverse of this is worth noting: the storm will increase in size and in total strength, although perhaps not in central intensity, as long as the updraught is active enough to throw some of its volume outside of the area occupied by the surface-indraught; for then the pressure at the centre will decrease, and the development of the embryo will continue.

Before proceeding to the consideration of tornadoes, we may devote a little space to the special features of our own storms east of the Rocky Mountains, as determined chiefly by Professor Loomis in his careful study of the signal-service maps.

The storm-areas, as indicated by the curved lines of equal pressures, are ovals about twice as long as wide, with the longer axis generally north-east and south-west. The average direction of progression of nearly five hundred storms, in 1872–74, was north 81° east, with a mean velocity of twenty-six miles an hour, or six hundred and twenty-four miles a day: the maximum velocity was above eighteen hundred miles a day. Some of these barometric depressions begin on the Pacific Ocean, or in our north-western territories; most of them are first noted within the western mountainous district; and a good share of the remainder arise on the plains. Very few come from the West Indies. After passing us, they sweep out over the ocean, generally turning well to the north-east, and, if continuing long enough, running to Norway or Iceland rather than to Great Britain. The probability that a storm which leaves our coast will arrive in England is only one in nine. The average tracks of a large number of storms from the Rocky Mountains to the Ural are shown on the accompanying map, prepared by Köppen (*Annalen der hydrographie*, 1882).

If storms moved only according to these averages, their prediction would be made easy and accurate; but they naturally fail to do so, and hurry or slacken their pace, or turn to one side or the other of their average course, in what seems to be the most capricious fashion. It is the early discovery of these individual peculiarities that tasks the acuteness of the weather-men.

With regard to velocity, storms advance much faster in February than in August (174 : 100), and in the late afternoon and evening than at other hours (125 : 100). If the telegraphic reports show a rapidly rising barometer, and a weak wind in the rear of the storm, it will probably move rapidly. The rain, also, exercises a marked control on the storm, as is shown by comparing the forward extension of the rain-area with the rate of progress: —

Forward extension of rain.	Progression of storm-centre.
640 miles.	40.1 miles an hour.
568 "	29.2 " " "
539 "	22.3 " " "
422 "	15.3 " " "

further, by comparing the axis of the rain-area with the course of the storm: —

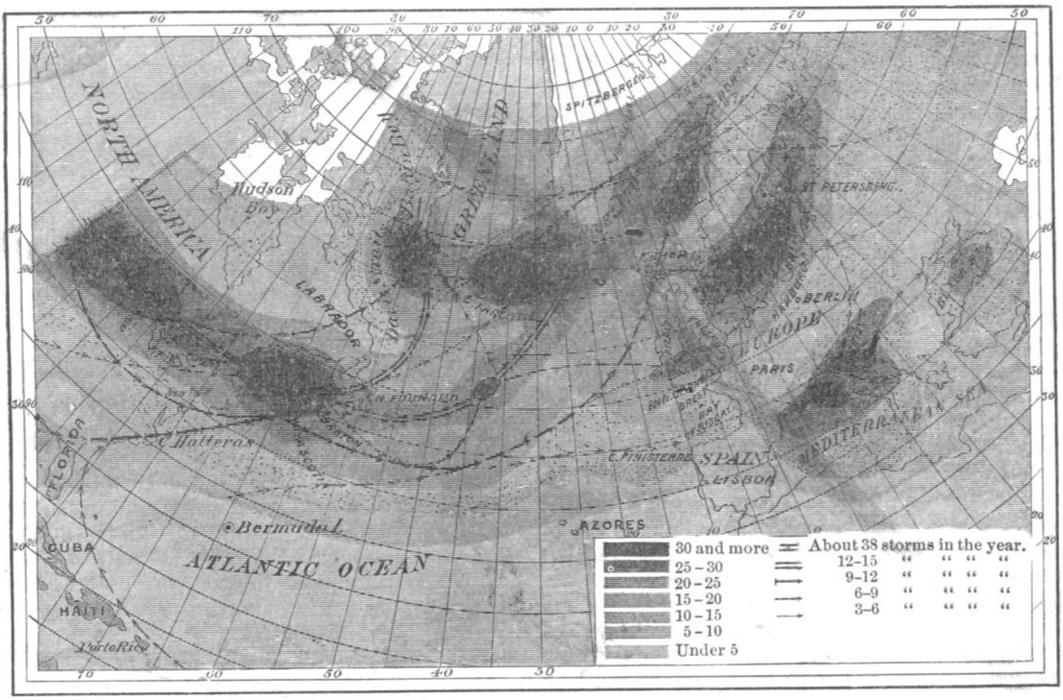
Axis of rain-area.	Course of storm.
N. 53° E.	N. 44° E.
S. 65° E.	S. 69° E.

finally, by comparing the rainfall with the increase or decrease of the central barometric depression: —

Average rainfall within isobar 29.80″.	Change of central depression in twenty-four hours.
0.078″	+ 0.10″ (i.e., storm decreasing).
0.149	− 0.05
0.159	− 0.128 (i.e., storm increasing).

Rain, therefore, is shown to aid in determining the velocity, direction, and development of our storms, as has already been inferred.

Thus far in regard to the motion of the storm tions here shown has already been discussed. It should be added, that the unexpected approach to equality in the wind's strength on the right and left (south and north) sides of the storm is probably in large part due to the wind on the north coming but little retarded from the sea, while that on the south has lost much of its proper velocity by blowing long over land; so that, while the winds should theoretically show a less velocity on the left than on the right side of the track when the storm moves over a uniform surface, this inequality might be largely



AVERAGE TRACKS OF STORMS FROM THE ROCKY MOUNTAINS TO THE URAL.

as a whole. The winds of the storm blow faster, the more marked the central depression and the closer the isobars. If the space on the signal-service maps between adjoining isobars (the difference of their pressure being one-tenth of an inch) measure one hundred and thirty miles, the wind will probably blow five miles an hour; if eighty miles, thirty miles an hour; if forty-five miles, fifty miles an hour. There is, however, much variation from this rule, depending on the form of the ground and the neighborhood of the lakes or the sea. The average direction, inclination, and velocity of our storm winds in the four quadrants is shown in fig. 21. The relation of the several inclina- counteracted by the relations of sea and land that obtain in the eastern part of our country. This is confirmed by finding the winds on the left side of the storms of northern Europe much weaker than on the right; for here the progression of the storm, and the relation of sea and land, combine to produce this effect. Our space forbids more detailed consideration of the variation of our storms with the seasons; and the reader desirous to pursue the subject farther should provide himself with the government daily weather-maps, which may be had by subscription to the chief signal-officer in Washington, and should consult Professor Loomis's essays in the *American journal of science* for

recent years, the circular on the practical use of meteorological reports and weather-maps (issued by the signal-service, 1871), and the appendices on the relation of rain and winds, and on the course of storms in the different months, in the signal-service reports for 1878 and 1874.

(To be concluded.)

THE INTELLIGENCE OF BATRACHIANS.

IN his recent volume on Animal intelligence,[1] Mr. Romanes devotes less than two pages to the intelligence of batrachians. He remarks, 'On the intelligence of frogs and toads very little has to be said.' That our author should have included toads in the above seems strange; as instances of cunning, and proofs of the general intelligence, of these animals, are numerous. In conversation with practical observers of animal life, I have never yet found one that did not accord a marked degree of intelligence to toads. In short, toads may readily be tamed, will come when called, and have been seen to place matter attractive to flies, their principal food, near their hiding-places, so they could remain at home and at the same time be sure of a sufficiency of food. This evidence of foresight, on the part of toads, is no uncommon occurrence, and quite effectually establishes their claim to a creditable degree of intelligence.

Of the spade-foot or hermit toad (Scaphiopus solitarius) and the tree-toad (Hyla versicolor) I have but little to record. The former is but rarely seen, and I have had no opportunity to experiment with it with a view to testing its mental capabilities. The habits of the animal, as described by Agassiz and Putnam, would lead one to conclude that intellectually they are to be classed with the common toad. The tree-toad, or Hyla, being crepuscular in habits, was found difficult to study, and nothing was determined that bore upon the question of its intellectual capacity. I can but state my impression, which is, that they are not so cunning as the common toad.

On the other hand, I am pained to confess that my many observations and experiments with the several species of true frogs found here, conducted without an intermission for four months, have yielded but little evidence that these creatures possess a particle of intelligence. It almost proved, indeed, to be labor lost, —

'To perch upon a slippery log,
And sit in judgment on a frog.'

[1] Animal intelligence. By George J. Romanes. (Internat. sc. series, no. xliv.) New York, *Appleton & Co.*

Mr. Romanes remarks, that, if frogs are removed to a long distance from water, they will take the shortest route to the nearest pool or brook. Even this, I find, is only usually true. Quite ten per cent of such 'removed' frogs started off, when released, in the direction of the most distant water, rather than that which was nearest. One of my many experiments was as follows: I placed a pail filled with water in a dry, dusty field, burying it to the brim. It was protected by a cap of coarse wire sieving. I then liberated a frog within twenty yards of it. It hopped in the opposite direction, towards water nearly three hundred yards distant. I then placed a frog on the opposite side of the buried pail, so that the distant brook could only be approached by passing near or directly over it, if the frog took a direct course. This the frog did, and less than a score of leaps brought it to the water covered by the sieve. It seemed quite satisfied with the fact that a little water was in sight, although out of reach. Here the frog remained until morning. The following day I removed the pail, and buried it within fifty yards of a running brook. I then took seven frogs of three species, and placed them upon the sieve, which was about half an inch above the surface of the water. Here five of them remained during the whole day, exposed to the glare and heat of a cloudless midsummer day. The evaporation from the water beneath them barely kept them alive; and yet within so short a distance was a running brook, with all the attractive features of ideal frog-life.

I repeated this experiment, with slight modifications, several times, and always with essentially the same results.

In his Travels in North America (Eng. trans., vol. ii. p. 171), Peter Kalm refers to certain habits of the bull-frog (Rana Catesbyana) which seemed to indicate that the frogs of this species occupying the same pond were somewhat governed by a leader. His remarks are, "When many of them croak together, they make an enormous noise. . . . They croak all together, then stop a little, and begin again. It seems as if they had a captain among them: for, when he begins to croak, all the others follow; and, when he stops, the others are silent;" and he adds that the 'captain' apparently gives a signal for them to stop. This, if true, would be evidence of considerable intelligence; but it is only apparently true of them. I have very carefully watched the bull-frogs in a pond near my house, and have found that the croaking of the 'captain' is not always that of the same individual. At times